THE INTERACTIVE EFFECTS OF QUALITY AND QUANTITY PARAMETERS ON WINTER WHEAT VARIETY AND HYBRID ON CHERNOZEM SOIL

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ABSTRACT

Wheat production is a determining branch within Hungarian crop production (near 1 million hectares). Weather anomalies caused by climatic change confirmed the importance of biological basis (variety, hybrid) in wheat production. The adapting ability and reaction of different wheat genotypes towards nutrient supply were studied in a long-term field experiment on chernozem soil type in case of different pre-crops (sweet corn, sunflower and maize). According to the experimental results of the vegetation 2017/2018 the most highest yield amount of the variety Ingenio sown after the pre-crop sunflower ranged between 2710 kg ha^{-1} and 8710 kg ha^{-1}, while the hybrid (Hyland) in case of the pre-crop sweet maize between 6556 kg ha^{-1} and 9270 kg ha^{-1} depending on the applied nutrient supply level. The studied genotypes showed the highest quality (protein, gluten) in case of the pre-crop sweet maize. In the cropyear of 2017/2018, the protein content of Ingenio ranged between 12.2-14.8%, while the Hyland in case of the pre-crops sweet corn between 9.9-13.9%. The gluten content of the Ingenio genotype changed between 24.9-32.5%, in the case of Hyland ranged between 16.9-27.3% in the studied cropyear.

Keywords: wheat, genotype, forecrops, yield, quality, fertilization

INTRODUCTION

Wheat production (nearly 1 million hectares) is the dominant sector of domestic crop production. The importance of winter wheat lies in its nutritional value (optimal balance of carbohydrates and protein content), its high ecological adaptability, and can be cultivated with full mechanization. The world's population is growing rapidly, requiring higher quality and higher yields (KRALJEVIC ET AL., 2007). The balanced nitrogen supply in the operation of sustainable agriculture is a worldwide problem. The nutrient supply of plants is based on two pillars: the nutrient supply capacity of the soil and the supply of artificial nutrients (JUHOS, 2015; LÁSZTITY ET AL., 1994). Increasing the genetic potential of winter wheat is basically dependent on the genotype and the agronomic interventions used (THRETHOWAN ET AL., 2012). Different ecological factors, agrotechnical elements (crop rotation, nutrient supply, irrigation, plant protection) fundamentally influence the quantity, stability and quality of the crop (PEPÓ, 2010). According to Pepó (2004), the rate of crop fluctuation in Hungary is higher than in other EU member states. Another determining factor in agricultural production is the high degree of climate variability. In recent decades, fluctuations in temperature and precipitation have become a decisive factor (HOFFMAN ET AL., 2007). This can be manifested in an increase in the average amount of precipitation or in the frequency of prolonged drought periods. In many cases, traditional varieties, under these extreme conditions, cannot realize their inherent genetic potential. In contrast to traditional varieties, the vitality, physiological activation and stress tolerance of hybrid wheat are much higher. As a result of the heterosis effect, the hybrid wheat has a higher yield potential. In addition, they have superior stress tolerance in droughty years, with poor soil conditions and prone to drought, and their crop stability is higher than traditional varieties. According to the results of Indian experiments, the cultivation of hybrid wheat

does not require more intensity than the technology of other cultivated winter wheat varieties (MATUSCHKE ET AL., 2007). In contrast, some research shows that winter wheat hybrids have higher yield potential, but the content of protein, alpha, and beta gamma gliadin is much lower (BUCZEK ET AL., 2016).
Our aim of these experiments and their results was to develop new technological solutions that can determine the pre-growth and nutrient response of the different genotypes of wheat, bearing in mind the elements of sustainable crop production. Our further objective is to develop crop production models and suggestions that will make it more efficient for farmers to grow their winter wheat with appropriate yield and protein and gluten content value.

MATERIALS AND METHODS

The University of Debrecen Institutes for Agricultural Research and Educational Farm Experimental Plant Látókép is located on the Hajdúság loess slate, about 15 km far from Debrecen. The soil of the experimental area is flat, balanced, geologically the chernozem type of lime-slag. The weather of the 2017/2018 breeding year was overall unfavourable. The mild autumn months followed by the gradual cooling of the rainy weather had a positive effect on the growth and initial development of the winter wheat and its tillering. February and March were colder than the average, so this had a negative impact on the development of wheat crops. During the vegetative development phase of winter wheat, April and May also had a negative effect on plant development and greatly reduced the phenological stages. The ripening of the stock occurred 1.5-2 weeks before the average. The experiment's forecrop was sunflower, corn and sweet corn. In the experiment, an early ripening group of mill-quality, whitish-wheat-type wheat, Ingenio, and winter wheat hybrids of outstanding vitality and high vintage stability in the late maturity group were examined by Hyland. On October 4, 2017, the optimal number of seeds of hybrids and hybrids was rejected with the Sulky seed drill in autumn. The long-term experiment was set up in the autumn of 1983. The field experiment was set in 4 replicates in a split-band arrangement. The plant protection applied in the experiment (weed control, twice fungicide, insecticide) met the requirements of modern cultivation. The winter wheat was harvested on July 1, 2018 with a Sampo plot harvester. The resulting crop results were processed using Microsoft Excel and SPSS for Windows programs. The results were evaluated by two-factor analysis of variance, based on the method of Sváb (1981) and Pearson's correlation analysis.

RESULTS

After sweet corn, corn and sunflower pre-harvest, the Hyland winter wheat hybrid reached higher yields at the control nutrient level (2458-6556 kg ha^{-1}). After harvesting corn, a relatively high yield was obtained in the control treatment (6556 kg ha^{-1}). The smallest crop of the two genotypes, at the control nutrient level in the 2018 breeding year, was the corn seedlings (*Table 1*).

1. Table: The effect of crop rotation and fertilization on the yield of winter wheat (Debrecen, Chernozem soil, 2018)

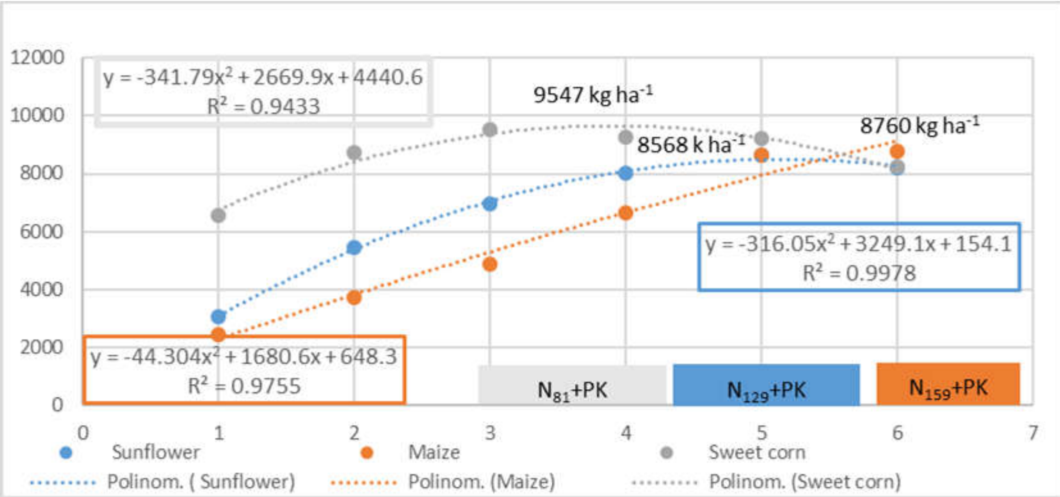
Genotype	Ingenio	Hyland	Ingenio	Hyland	Ingenio	Hyland
Forecrop	*Sweet corn*		*Maize Corn*		*Sunflower*	
Nutrient level	**Yield kg ha^{-1}**					
Controll	6010	6556	2027	2458	2714	3071
N_{90}+PK	7816	9270	7486	6650	8710	8017
N_{150}+PK	7488	8264	8361	8760	8708	8206
LSD5% Genotype	***499***					
LSD5% Forecrop	***1389***					
LSD5% Nutrient level	***774***					

In both genotypes, the nutrient levels increased, and the maximum yields are also increased. In the case of Ingenio winter wheat breed, we found that there was a significant difference between control and fertilizer treatments. The maximum yield was at the N_{90} + PK nutrient level (8710 kg ha^{-1}). The hybrid wheat has already reached its maximum yield (9270 kg ha^{-1}) after sweet corn pre-harvest at lower nutrient levels (N_{90} + PK). After the more unfavourable pre-cultures (corn, sunflower) the higher (+ PK) fertilizer dose proved to be optimal for the Hyland hybrid (8760 kg ha^{-1}and 8206 kg ha^{-1}). In the sweet corn pre-harvest, the Hyland hybrid wheat fertilization yielded 2714 kg ha^{-1}, the Ingenio wheat variety yielded 34% less (1806 kg ha^{-1}) yield (*Table 1*). The yield of hybrid wheat was 6302 kg ha^{-1} after maize and 5132 kg ha^{-1}after sunflower. After the forecrop Ingenio-type maize, a higher yield (6334 kg ha^{-1}) was achieved at the level of N_{150} + PK, while a higher yield surplus (5996 kg ha^{-1}) was observed after sunflower harvest at a lower fertilizer dose.

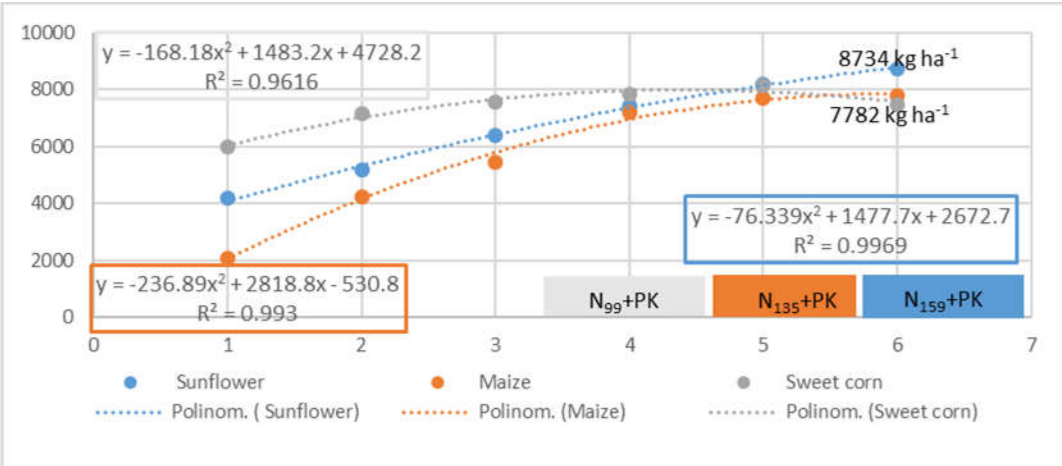
2. Table: Relationship between genotype, forecrop, fertilization, and quantitative and qualitative indicators by Pearson's correlation analysis

	Yield (kg/ha^{-1})	**Protein content (%)**	**Gluten content (%)**
Forecrop	-0.166	-0.344**	-0.386**
Genotype	0.044	-0.431**	-0.382**
Nutrient level	0.747**	0.665**	0.676**

Using Pearson's correlation analysis, it can be concluded that there was a close positive relationship between ration of nutrient management and yield (r = 0.747 **). In the 2018 breeding year, the forecrop (r = -0.116 **) and the genotype (0.044 **) had no effect on the yield of winter wheat *(Table 2).* Using the regression analysis of the variety and hybrid nutrient optimum *(Figure 1.),* it can be stated that under the given conditions, the optimal NPK dose of Hyland hybrid after sunflower pre-harvest at $N_{120-129}$ + PK nutrient level, while maize forecrop $N_{150-159}$ + PK nutrient level, after sweet corn N_{81-90} + PK level.



1. Figure: Analysis of nutritional reaction of Hyland hybrid wheat (Debrecen, 2018)



2. Figure: Analysis of the nutrient reaction of wheat of the Ingenio breed (Debrecen, 2018)

Optimal fertilizer doses differ for the two genotypes. Based on these results, we found that for the Ingenio variety, the optimum fertilizer interval was $N_{120-135}$ + PK after sunflower, sweet corn forecrop $N_{120-135}$ + PK, and N_{90-99} + PK in the case of sweetcorn forecrop *(Figure 2)*. In the 2018 breeding year, after the sweet corn, the gluten content of the Ingenio breed developed favourably *(Table 3)*. After sweet corn, the gluten content ranged from 24.98% up to 32.50%. The Hyland winter wheat hybrid showed less wet gluten content (19.20% -27.35%) than the Ingenio variety in all three different nutrient treatments.

3. Table: Impact of precrop, genotype and fertilization on wet wheat content of winter wheat (Debrecen, 2018)

Genotype	**Ingenio**			**Hyland**		
Forecrop	*Sweet corn*	*Maize*	*Sunflower*	*Sweet corn*	*Maize*	*Sunflower*
Nutrient level	**Gluten content (%)**					
Control	24.98	18.08	17.95	19.20	16.98	18.43
N_{90}+PK	31.00	28.05	25.80	26.73	24.73	20.43
N_{150}+PK	32.50	28.73	28.65	27.35	25.45	22.30
LSD% Genotype	**0.92**					
LSD% Forecrop	**1.31**					
LSD% Nutrient level	**2.69**					

After sweet corn, we found a statistically verifiable difference between the hybrid gluten content of winter wheat at each of the three nutrient levels. Compared to the results of the control plots, each additional nitrogen dose increased to a different extent, but increased in the gluten content of both genotypes. In the case of Ingenio breed, the growth was nearly 10%, while in the case of Hyland hybrid wheat, the growth was almost 9%. Both genotypes achieved the highest gluten content at the N_{150} + PK nutrient dose (32.50%, 27.35%). On the basis of the results, the winter wheat showed weaker values by 4-6% compared to the breed. In the case of maize forecrop *(Table 3),* the results of control treatment showed that this forecrop had an adverse effect on the gluten content of both genotypes. In control treatment, the content of gluten varied between 17.95% and 24.98% for Ingenio winter wheat. The highest value was measured after sweet corn, the smallest after sunflower. However, we only found a significant difference in the values of sweet corn and maize and sweet corn and sunflower. Examining the results of the Hyland wheat hybrid, it was found that there was a statistically verifiable difference between the three precrops. The wet gluten content ranged from 16.98% to 19.20%. In the case of hybrid wheat, the smallest gluten content was found in maize (16.98%) and highest in sweet corn (19.20%) in the 2018 breeding year *(Table 3).* The correlation between nutrient management, precrop, genotype and the examined quality indicators was investigated by Pearson's correlation analysis (*Table 2*). Nutrient supply significantly influenced the gluten content of winter wheat that were established a close significant relationship (r = 0.665 **). The gluten content values were also modified by the forecrop and genotype, i.e. there was a moderate negative relationship (r = 0.386 ** and r = 0.382 **). Based on data from the 2018 breeding year, we found that for all three precrops the maximum protein content was the lowest on the control plot *(Table 4).* By increasing the nutrient doses, to a different extent than the two genotypes, the protein content increased. The highest protein content at the N_{150} + PK level was produced by the Ingenio breed (14.80%), after sweet corn seedling. Comparing the results of the two genotypes, the highest level of crude protein was found after the sweet corn at the control nutrient level, in the Ingenio winter wheat breed (12.25%). After harvesting maize and sunflower, this value has been moderately reduced. The Hyland hybrid, like the variety, achieved a higher protein content of sweet corn (10.20%). After sunflower pre-harvest, the protein content (10.10%) was more favourable than after maize (9.93%).

4. Table: Impact of forecrop, genotype and fertilization on protein content of winter wheat (Debrecen, 2018)

Genotype	**Ingenio**			**Hyland**		
Forecrop	*Sweetcorn*	*Maize*	*Sunflower*	*Sweetcorn*	*Maize*	*Sunflower*
	Protein content (%)					
Nutrient level						
Control	12.25	9.98	9.93	10.20	9.40	10.10
N_{90}+PK	14.33	13.68	12.78	12.80	12.23	10.68
N_{150}+PK	14.80	13.95	13.80	12.95	12.33	11.18
SZD5% Genotype	**0.28**					
SZD5% Forecrop	**0.97**					
SZD5% Nutrient level	**0.46**					

By increasing the nutrient doses, the protein content was different to the two genotypes but increased. The highest protein content at the N_{150} + PK level was produced by the Ingenio breed (14.80%), after sweet corn. At Hyland winter wheat hybrid we measured a lower protein content compared to the breed. Its best protein content was 12.15% after sweet corn. Using Pearson's correlation analysis, it can be concluded that there was a strong (r = 0.665 **) positive relationship between nutrient management and protein content, thus, significant increase in protein content was achieved by increasing nutrient doses. In the 2018 breeding season, there was a moderate negative relationship between the winter wheat genotypes and the pre-crop (r = -0,344 **) and the genotype (-0,431 **).

CONCLUSION

The weather anomalies caused by climate change in wheat production have increased the role of biological foundations (breed, hybrid). According to the results of our 2017/2018 experiments, the yield of the Ingenio breed after sweet corn forecrop is 6010-7816 kg ha^{-1}, after maize forecrop 2027-8361 kg $ha^{-1}$and after sunflower 2714-8710 kg ha^{-1}depending on fertilizer treatment. In the case of Hyland's winter wheat, the yield of the hybrid is 6556-9270 kg ha^{-1}, after maize forecrop 2458-8760 kg $ha^{-1}$and after sunflower 3071-8206 kg ha^{-1} depending on fertilizer treatment. In the given year the two genotypes showed different quality (gluten, protein) parameters. In the case of Ingenio breed, the content of protein after sweet corn forecrop varied from 12.25% to 14.80%, after maize was 9.98-13.95%, after sunflower was 9.93-13.80% depending on fertilizer treatment. Winter wheat hybrid had moderately less protein content in the year under review. For various fertilizer treatments, the protein content of wheat was 10.20-12.95% after maize forecrop, 9.40-12.33% after sunflower, 10.10-11.18%. Winter wheat gluten content for Ingenio breed, depending on the amount of fertilizer dose, was 24.98-32.50% for sweet corn forecrop, 18.08-28.73% for corn, and 17.95-28.65% for sunflower. In contrast, hybrid wheat produced lower quality in the breeding year 2017/208. The content of gluten varied between 16.98 and 27.35%, depending on the forecrop and nutrient levels.

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